Newton's Second Law

TOPICS AND FILES

Mechanics Topics

Newton's Second Law, constant force

Newton's Second Law, find the mass

Atwood Machine

Capstone Files

15B Newton's 2nd Law 2.cap

16 Push-Pull a Cart.cap

18 Atwood's Machine.cap

EQUIPMENT LIST

Qty	Items	Part Numbers
1	PASCO Interface (for one sensor)	
1	Motion Sensor	CI-6742
1	1.2 m Dynamics Track	ME-9435A
1	Dynamics Cart	ME-9430
1	Mass and Hanger Set	ME-9348
1	Balance	SE-8723
1	Smart Pulley (photogate) with Clamp	ME-9448
1	Force Sensor	CI-6746
1	Universal Table Clamp	ME-9376B
1 m	String	SE-8050
2	250 g mass bar	

INTRODUCTION

The purpose of Experiment 1 is to find out what happens to an object's acceleration when the net force applied to the object changes and the mass of the system is held constant. You will then examine the inverse situation - a system under the influence of a constant force but variable mass. Use a motion sensor to measure the motion of an object that is accelerated by a net force. Use *Capstone* to record the motion. Determine what happens to the acceleration of the cart when the net force is kept constant and the mass changes, and then what happens when the mass is kept constant but the net force changes.

The purpose of Experiment 2 is to find the mass of a system by applying a known force and measuring the acceleration. Use a motion sensor to measure the motion of an object that is accelerated by a force. Use the force sensor to measure the amount of force applied. Use *Capstone* to record the force and the motion. Determine the mass of the system based on the applied force and the acceleration.

The purpose of Experiment 3 is to study the relationship among force, mass, and acceleration using an Atwood's Machine apparatus. Use the photogate/pulley system to measure the motion of both masses strung over a pulley as one moves up and the other moves down. Use *Capstone* to record the changing speed of the masses as they move. The slope of the graph of velocity vs. time is the acceleration of the system.

BACKGROUND

Newton's first law of motion states that if no net force acts on an object, then the velocity of the object remains unchanged. The second law of motion deals with what happens when a net force does act.

$$\vec{a} = \frac{\vec{F}_{\text{net}}}{m} \tag{1}$$

As long as a net force acts, the velocity of an object changes - in other words, it accelerates. If more force is applied, the greater force produces a greater acceleration. Twice the force produces twice the acceleration. Often, several forces act on an object simultaneously. In such cases, it is the net force, or the vector sum of all the forces acting, that is important. Newton's second law states that the acceleration is proportional to the net force acting on the object.

$$\vec{a} \propto \vec{F}_{\text{net}} \tag{2}$$

Newton's Second Law also states that the acceleration is inversely proportional to the mass.

$$\vec{a} \propto \frac{1}{m} \tag{3}$$

The acceleration of an object depends on the net applied force and the object's mass. In an Atwood's Machine, the difference in weight between two hanging masses determines the net force acting on the system of both masses. This net force accelerates both of the hanging masses; the heavier mass is accelerated downward, and the lighter mass is accelerated upward.

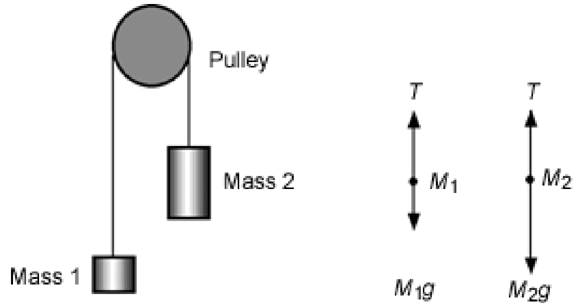

Figure 1

Based on the above free body diagram, T is the tension in the string, $M_2 > M_1$, and g is the acceleration due to gravity. Taking the convention that up is positive and down is negative, the net force equations for M_1 and M_2 are:

$$T_1 - M_1 g = F_{\text{net}} = M_1 a \tag{4}$$

$$T_2 - M_2 g = F_{\text{net}} = M_2(-a) \tag{5}$$

Assuming that the pulley is massless and frictionless, and the string has no mass and doesn't stretch, let $T_1 = T_2$. Solving for a, the acceleration of the system of both masses, the theoretical acceleration is g times the difference in mass divided by the total mass.

$$a = g\left(\frac{M_2 - M_1}{M_1 + M_2}\right) \tag{6}$$